MICROSTRUCTURES OF SELECTED SPECIES OF THE DIATOM DENTICULA

by

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CONTENTS

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INTRODUCTION:

The intent of this investigation has been to describe microstructures of the frustules of *Denticula* and, in so doing, to answer certain taxonomic questions that have resulted from incomplete knowledge of those structures. Particular attention has been paid to the affinities between *D. hyalina* Schrader and *D. homoantarctica* (*D. antarctica* McCollum, non *D. antarctica* Grunow) as suggested by Schrader (in press), and between *D. lauta* and *D. dimorpha*, as noted by this author. These problems are addressed in the taxonomic section of this paper.

Traditionally the description and classification of various species of *Denticula* have depended largely on the features of the valve surface. Relative neglect of structures of the diatom girdle, or cincture (Fig. 2), has resulted in an incomplete and often inaccurate knowledge of that region. This is due, in part, to the limitations of light microscopy, which has, until recently, been the mainstay of micropaleontological studies. Increasing application of scanning electron microscopy to diatom paleontology (and, indeed, to diatom research in general) has facilitated study of the girdle (Round, 1972; Von Stosch, 1974).

Another deterrent to an understanding of the order and orientation of the various elements in a *Denticula* frustule is the ready disarticulation of the fossil organisms. In addition to the damage caused naturally by the processes of sedimentation and solution of the siliceous frustule, further separation of the elements, Round suggests, are caused in the laboratory by the common methods of preparation, which involve boiling the samples in concentrated acids (Round, 1972). This author has attempted to minimize this secondary damage by employing gentler methods of sample preparation.

MATERIALS AND METHODS:

Sample materials used in this study come from several sources. Sediments from core sites 328 and 329 were taken aboard the Glomar Challenger during Leg 36 of the Deep Sea Drilling Project, and were made available to me by Dr. D. H. Elliot. Samples from core site 173 (DSDP Leg 18) and Eltanin core 36-16 were contributed by the Antarctic Research Facility at Florida State University. Information concerning the locations and stratigraphy of these cores may be found in the Initial Reports of DSDP Legs 36 (Gombos, in press) and 18 (Schrader, 1973), and the Eltanin Core Descriptions (Frakes, 1971), respectively. Material from Newport Bay, California was donated by Fred Weaver. Location and stratigraphic position of this material were discussed by Ingle (1973) and Wornardt (1973).

Approximately 5 cc of material from each sample were placed in a 200 ml beaker with 100 ml of distilled water. Alconox was added in small amounts as necessary to disassociate the sediments and disperse the clays they contained. The material was then washed through 75μ and 44μ screens and placed in clean, labeled vials for storage. Using temporary wet slide preparations, each size fraction was surveyed for the occurrence of Denticula. Only the fraction finer than 44μ contained significant numbers of individuals of this genus.

Microscope slides were made of the fine fraction of each sample by withdrawing from the center of the sample bottle a portion of suspended material with a disposable pipette. Two or three drops of the suspension were spread on a 22mm x 40mm coverslip and allowed to dry. Each coverslip was mounted to a glass slide with 3 drops of Caedex mounting medium, and heated. The slides were studied at 125x to 650x with a Zeiss or a Leitz petrographic microscope.

Samples that contained *Denticula* in numbers sufficient to facilitate further studies on the electron microscope were treated to remove the calcareous nannoplankton and any organic substances present. Approximately 1 cc of each of these samples was placed in a centrifuge tube with 50 ml of distilled water and several drops of dilute HCl. When the chemical activity subsided, the samples were centrifuged at 2000 rpm and decanted. The process was repeated three times to concentrate the diatoms, twice diluting with 50 ml of distilled water, and once with 50 ml of 0.5% sodium pyrophosphate. Samples in which the specimens were particularly fragile were not centrifuged, but the suspension was allowed to settle 10 hours before decanting.

Samples were prepared for SEM study by drying a drop of suspended material on a coverslip affixed to a stub, and coating with carbon and gold palladium.

REVIEW OF THE LITERATURE:

When Kützing defined *Denticula* in 1844 little was known about the structures of diatom girdles. Von Stosch (1974) believes that the earliest work in this region was done by Müller in the mid 1880's. This early work was very basic, and dealt with the gross morphology of the bands of the girdle. In 1886 Müller described open bands and closed bands (Von Stosch, 1974). Since that time much literature has emerged on the subject of diatom structure and morphology. A comprehensive volume on diatoms was published in 1966 by Patrick and Reimer. Further studies of the girdle have been executed by Round (1972), Von Stosch (1974), and others.

Simonsen and Kanaya (1961) cited the need to study *Denticula* and to revise the genus. They described the taxonomy and stratigraphic distribution of the five marine species of *Denticula* known at that time. Four of these species are extinct. Among these are *D. hustedtii* and *D. lauta*, which are dealt with in this paper. Simonsen and Kanaya's microstructural descriptions of the valves were quite accurate. Their descriptions of girdle elements, however, were inexact, as is discussed in the taxonomic section in intercalary bands.

The taxonomy of several extant, fresh-water species of *Denticula* has been discussed by Patrick and Reimer (1975).

In 1973 Schrader defined two new species of *Denticula*, *D. hyalina* and *D. dimorpha*. In a separate paper, Schrader discussed the taxonomy and stratigraphic distribution of the recognized marine species of

Denticula which, by 1973, included 9 species and 3 varieties.

Denticula homoantarctica (Pl. 1, figs. 6-13; Pl. 3, fig. 10) was first defined by McCollum (1975) who called it D. antarctica. The validity of this species as a biological entity was questioned by Schrader (in press), who suggested that it might be conbined with D. hyalina.

In response to a growing need for uniformity in diatom literature, new standards of terminology and form of diagnosis were proposed at the Third Symposium on Recent and Fossil Diatoms at Kiel, Germany (Anonymous, 1974). I have conformed to these standards in part, but have retained some of the "old" terminology in an attempt to maintain continuity with the previous literature on Denticula.

TAXONOMY:

The symmetry and generalized components of the diatom frustule have been thoroughly discussed in other works (Patrick and Reimer, 1966; Hendey, 1964; Von Stosch, 1974), and are summarized in Figs. 1, 2 and 3.

Specimens of Denticula are rectangular in girdle view, and exhibit diagonal symmetry, due to the location of the raphes at diagonally opposite margins of the frustule. However, this symmetry is imperfect in individuals of species such as D. hustedtii (Pl. 2, fig. 1), and D. lauta (Pl. 3, fig. 1), in which the cingula of the two thecae are not alike.

The outlines of the valves of Denticula are elliptical to linear-elliptical, and may be slightly protracted at the ends. Deep valve mantles normal to the nearly flat valve faces are characteristic of members of this genus.

The valves of most species of Denticula, including D. hustedtii, D. lauta and D. denticulata, are areolate. The pores are arranged in decussate pattern, forming both transapical striae and oblique rows. There may be a reduction of the number of pores, as suggested by Schrader (1973), so that this pattern may not be constant between members of the same species. There are also changes in the pore pattern on a given specimen, so that generally the pore density is low on the valve face and abruptly increases at the margins and mantles (Pl. 2, figs. 2, 9).

There are, within the genus Denticula, two species that have hyaline valve faces, D. hyalina and D. homoantarctica. Both of these species, however, have areolate valve margins and mantles. Specimens of

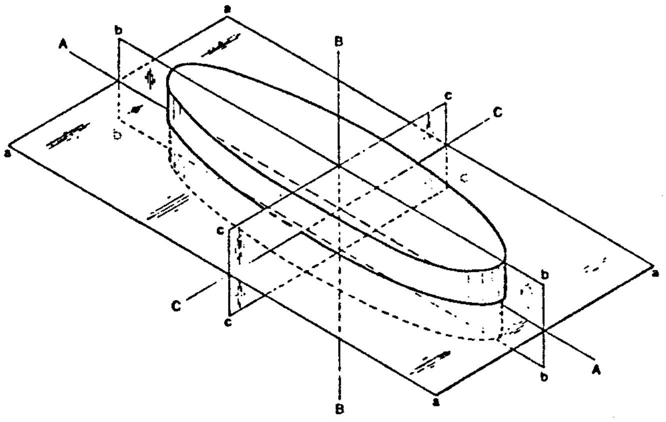


Fig. 1. Axes and planes of symmetry: apical axis A, pervalvar axis B, transapical axis C, valvar plane a, apical plane b, transapical plane c. From Hendey (1964).

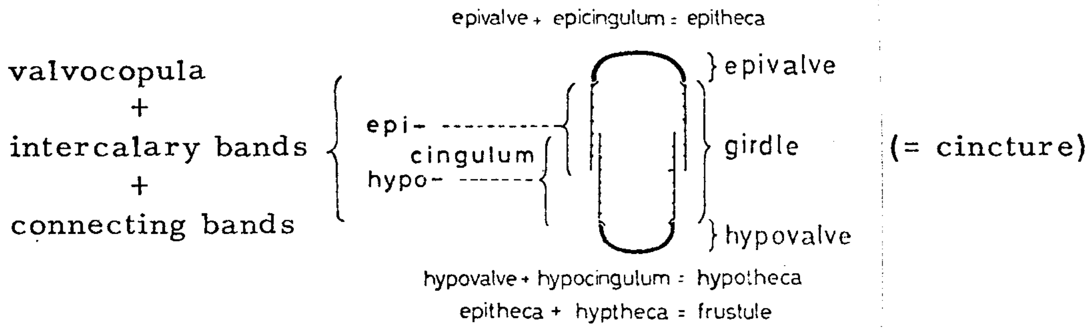


Fig. 2. Components of the frustule. From Von Stosch (1974).

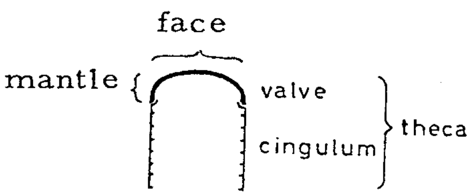


Fig. 3. Components of the theca. From Von Stosch (1974).

D. hyalina have mantle pores arranged in decussate pattern similar to that of the more fully areolate species discussed above. In these specimens there is clearly a double mantle wall, consisting of a coarsely porous basal layer overlain by a finely porous external layer (Pl. 1, figs. 1,5). This type of pore structure has been observed in a few specimens of D. hustedtii and D. lauta, but, certainly, it is not as well developed in these as in specimens of D. hyalina.

A completely different pore system is present in specimens of Denticula homoantarctica. Large pores are arranged in single apical rows along the margins of the valve and around the mantle. Each pore is occluded by a cribrum-type velum which is recessed from the exterior surface (Pl. 1, fig. 11). This type of pore structure is not typical of Denticula and, in fact, is represented in this genus only by specimens of D. homoantarctica.

The features common to all species of Denticula are the pseudosepta (Fig. 7), i.e., thickenings of the cell wall which deeply penetrate the interior of the valve, parallel to the transapical plane, and divide the cell into chambers. In members of several species the pseudosepta thicken toward the interior of the frustule, becoming subcapitate at the inner edge. This feature is strongly developed in specimens of D. hyalina (Pl. 1, figs. 3-5) and D. hustedtii (Pl. 2, figs. 4,6,7), and weakly developed in D. homoantarctica (Pl. 1, figs. 8,9). Simonsen and Kanaya (1961) stated that the pseudosepta of frustules of Denticula do not have capitate inner edges, but that these thickened "crossbars" are part

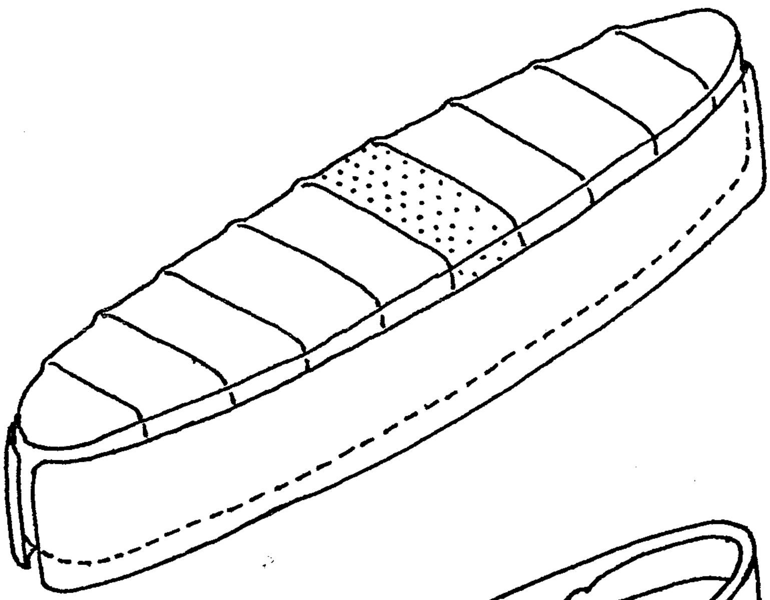


Fig. 4. Valve + cingulum type 1 (Valvocopula).

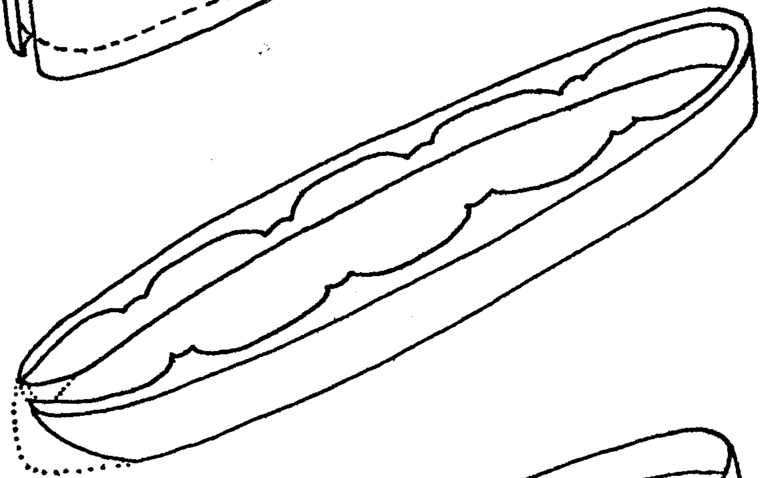


Fig. 5. Cingulum type 2 or type 3 (open or closed intercalary band without septum).

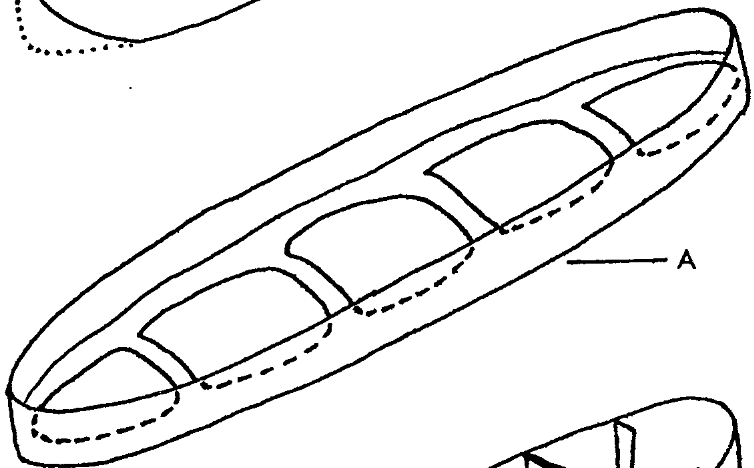


Fig. 6. Cingulum type 4, with septum A. From. Simonsen and Kanaya (1961).

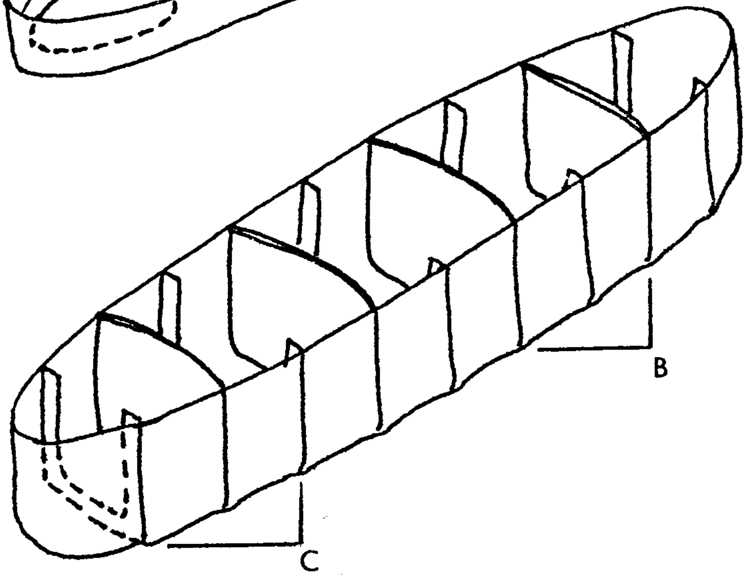


Fig. 7. Valve; pseudosepta B, secondary pseudosepta C. From Simonsen and Kanaya (1961).

of a septal plate. However, it is clearly evident that, in members of the three species mentioned, the "crossbars" are part of and continuous with the pseudosepta. The development of this form is coincident with the presence of intercalary bands which do not bear septal plates. Members of those species considered herein which do possess septa, i.e., D. lauta and D. denticulata, have pseudosepta which do not thicken at the inner edge (Pl. 3, fig. 4). Thus, the generalization set forth by Simonsen and Kanaya does not apply to all species of Denticula.

In addition to pseudosepta, members of some species of Denticula have secondary pseudosepta which do not penetrate the valves very deeply (Fig. 7),and short, rib-like wall thickenings. These features are adequately discussed in Simonsen and Kanaya (1961). Secondary pseudosepta are present in specimens of D. hustedtii and D. denticulata.

The cincture of the Denticula frustule may be composed of some combination of five types of cingula, including valvocopula, three types of intercalary bands, and connecting bands. The commonly accepted assumption that all intercalary bands of members of Denticula have septa (Simonsen and Kanaya, 1961) is erroneous. As mentioned in the discussion of pseudosepta, members of some species have intercalary bands with septal plates, whereas members of others do not.

The first type of cingulum is a weakly silicified, external, open band which overlaps the mantle of the hypovalve (Fig. 4). It has no septum. In most English literature (e.g., Round, 1972) this element is called a girdle band; according to the proposed standard terminology it would most likely be called a valvocopula (Anonymous, 1974). This type of band has been observed in specimens of D. hyalina (Pl. 1, fig. 1), D. homoantarctica (Pl. 1, fig. 13), D. hustedtii (Pl. 2, fig. 1), and D. lauta (Pl. 3, fig. 1). No such band has been observed even in well preserved specimens of D. denticulata.

A second type of cingulum is a moderately to strongly silicified, open intercalary band which abuts against the edge of the mantle (Fig. 5). This band also has no septum. The contact between the interior edge of this band and the valve is marked by sutures along both sides of the pseudosepta. This type of band constitutes the cingulum of both thecae in specimens of Denticula homoantarctica (Pl. 1 figs. 9, 13) and D. hyalina (Pl. 1, figs. 1,4) and of the epitheca in specimens of D. hustedtii (Pl. 2, figs. 6,7) and D. lauta (Pl. 3, fig. 6). It was probably this type of intercalary band to which Simonsen and Kanaya (1961) referred when they stated that "when isolated septa are seen, they almost always have lost their crossbars". As noted above, the crossbars in these cases are part of the pseudosepta and not of the intercalary bands.

A third form of cingulum is a strongly silicified, closed intercalary band without a septum (Fig. 5). This band joins the valve in much the same manner as does the open band just discussed. This third sort of band constitutes the hypocingulum of specimens of D. hustedtii (Pl. 2, fig. 3).

The fourth kind of cingulum is a strongly silicified, closed intercalary band which bears a septal plate (Fig. 6). The crossbars of the septum are continuous with the band and are not sutured at either end. Although the crossbars occationally break away from the band, this does not appear to be common. Each crossbar has, on the side toward the valve, a transapical groove which fits over the edge of the pseudoseptum (Pl. 2, fig. 10). This type of septum-bearing band makes up the cingulum of the hypotheca in specimens of Denticula lauta (Pl. 3, figs. 5,7), and of both thecae in specimens of D. denticulata (Pl. 2 , figs. 8-14).

The two septal plates of specimens of Denticula denticulata are joined by a fifth type of cingulum, a narrow, open-ended connecting band (Pl. 2, figs. 8, 12). On either side of this band is a row of denticles which fit into the depressions along the abvalvar edge of the intercalary bands. Analogous features have not been observed in members of any of the other four species studied, but might possibly be encountered in other species of Denticula.

<u>Denticula hyalina</u> Schrader, 1973
Plate 1, figs. 1-5

<u>Denticula hyalina</u> Schrader, 1973, p. 704, pl. 1, figs. 12-22.

<u>Description:</u> Frustule rectangular in girdle view. Pervalvar axis 8-12μ. Intercalary bands strongly silicified, hyaline, open at one pole; one such band per theca, the open ends of the two bands at opposite poles of frustule. Weakly silicified valvocopula overlapping mantle of hypovalve. Septa absent. Valves strongly silicified, elliptical to linear-elliptical, ends broadly rounded. Apical axis 10-40μ, transapical axis 4-9μ. Valve surface largely hyaline, with subtriangular wall thickenings at margins. Basal siliceous layer of valve margins and mantle perforated by coarse, circular pores generally arranged in decussate pattern; about 10 pores in 10μ, in an apical direction. Basal layer overlain by finely porous external layer, 45-49 pervalvar striae in 10μ. Raphe marginal; inner canal openings 3-5 in 10μ, one between each pair of pseudosepta. Pseudosepta, 3-5 in 10μ, thickened toward interior of frustule. Contact between pseudosepta and interior edge of intercalary band marked on both sides by suture. Secondary pseudosepta absent.

<u>Discussion:</u> Frustules of <u>Denticula hyalina</u> differ from those of <u>D. lauta</u> in that the valve surfaces are hyaline, mantle pores are coarser, there is no septum, and pores are lacking on either intercalary band. Frustules of this species also differ from those of <u>D. homoantarctica</u> by the finer, more numerous pores on the mantle, by the subtriangular wall thickenings on the valve surfaces, by the finely porous external layer on the mantle,

and by their generally shorter apical axes.

Schrader (1973) stated that the raphe, "in most cases", is located in the middle of the mantle. This was not observed in this study, in which all specimens, identified as Denticula hyalina on the basis of the other characteristics of the species, have raphes located on the margins of the valve surfaces.

Schrader (1973) found no intercalary bands in specimens of Denticula hyalina. However, intercalary bands are clearly evident in micrographs on plate 1 of this report. The previous misconception that all intercalary bands in specimens of Denticula bear complete septal plates is probably responsible for this oversight on Schrader's part.

Denticula homoantarctica, new name
Plate 1, figs. 6-13
Holotype: Plate 3, fig. 10

Denticula homoantarctica, new name

Denticula antarctica McCollum, 1975, p. 527, pl. 8, figs. 6-10.

Description: Frustule rectangular in girdle view. Pervalvar axis about 9-10μ. Intercalary bands strongly silicified, hyaline, open at one pole; one such band per theca, the open ends of the two bands at opposite ends of frustule. Weakly silicified valvocopula overlapping mantle of hypovalve, open at one end. Septa absent. Valves linear-elliptical, may be sightly protracted; ends broadly rounded. Apical axis 17-76μ, transapical axis 4-8μ. Valve surface hyaline, except for single row of large, subcircular pores at each margin, one pore between each pair of pseudosepta. Single row of large pores around mantle, one pore between each pair of pseudosepta. Each pore occluded by porous sieve membrane, or cribrum type velum. Raphe marginal. Pseudosepta 5-7 in 10μ, joined on either side to interior edge of intercalary band by suture. Secondary pseudosepta absent.

Discussion: Frustules of Denticula homoantarctica differ from those of D. hyalina by their coarser pore structures, by their recessed vela, and by their generally longer apical axes. The vela are fragile structures and may be observed only in well preserved specimens of D. homoantarctica.

Shortly after McCollum defined Denticula antarctica (1975) as a new species, Schrader noted it similarity to D. hyalina, and suggested that the two might be combined in the future (Schrader, in press). Comparison of micrographs of typical specimens provides clear evidence that the two are distinct and separate species. However, because the name D. antarctica had been previously used [D. antarctica Grunow, 1877-1882= Fragilariopsis antarctica (Castracane, 1886) Hustedt, 1913] (Van Landingham, 1969), the name Denticula homoantarctica is proposed for this species.

McCollum (1975) reported septa in specimens of this species. Schrader (in press) did not find septa in the specimens he studied and, likewise, did not report the presence of intercalary bands. There are, in fact, intercalary bands present, but these do not bear septal plates.

The holotype is kept in the Orton Museum of Geology at The Ohio State University and is catalogued under the number 32793.

Denticula hustedtii Simonsen and Kanaya, 1961
Plate 2, figs. 1-5

Denticula hustedtii Simonsen and Kanaya, 1961, p. 501, pl. 1, figs. 19-25.

Van Landingham, 1969, p. 1273 (complete synonymy through 1969)

Description: Frustule rectangular in girdle view. Pervalvar axis 10-12μ. Single intercalary band of epitheca strongly silicified, hyaline, open at one pole; intercalary band of hypovalve strongly silicified, hyaline, closed; valvocopula overlapping mantle of hypovalve, weakly silicified, open at one pole. Septa absent. Valves moderately silicified, elliptical to linear-elliptical, may be slightly protracted; ends broadly rounded. Apical axis 8-55μ, transapical axis 3.5-11μ. Valve surface perforated by fine, circular pores, transapical striae 22-29 in 10μ. Pores in decussate arrangement, forming oblique rows, 18-22 in 10μ. Pores finer and more numerous at raphe margin and on mantle, pervalvar striae 30-45 in 10μ. Raphe marginal; inner canal openings 6-7 in 10μ, one between each pair of costae. Pseudosepta, 3 in 10μ, thickened toward interior of frustule. Contact between pseudosepta and interior edge of intercalary band marked on both sides by suture. 1-3 secondary pseudosepta between each pair of pseudosepta; short, rib-like wall thickenings on both sides of mantle.

Discussion: In their definition of this species, Simonsen and Kanaya (1961) reported septa, the crossbars of which joined the main part of the septal plates by sutures at both ends. This interpretation has frequently been cited (Schrader, 1973; McCollum, 1975; Schrader, in press). However, in specimens of Denticula hustedtii the "crossbars" are part of and continuous with the valve. The sutures, then, mark the contact between the pseudosepta and the intercalary bands.

Frustule of Denticula hustedtii differ from those of D. lauta by the presence of secondary pseudosepta, by the absence of a row of pores on one intercalary band, and by the absence of septa. They differ from frustules of D. seminae by the coarser pores and fewer striae, and from those of D. denticulata by the lack of septa.

Denticula denticulata, new species
Plate 2, figs. 8-14
Holotype: Plate 3, fig. 9

Description: Valves rectangular in girdle view. Pervalvar axis 11.5-12.5 μ. Intercalary bands strongly silicified, hyaline, closed, bearing septa plates. One such band per theca. Crossbars of septa 3 in 10 μ; openings between crossbars commonly irregular in size and shape. Row of depressions around abvalvar rim of intercalary bands. Septa joined by narrow connecting band, which bears tooth-like projections (denticles) on both sides. Valves elliptical to linear-elliptical, may be slightly protracted; ends broadly rounded. Apical axis 13-36 μ, transapical axis 8-11 μ. Valves perforated by fine, circular pores; on valve surface pores in decussate arrangement, forming transapical striae 21-30 in 10 μ, and oblique rows 16 in 10 μ; pores finer, more numerous at margins and on mantle, 38-50 pervalvar striae in 10 μ. Raphe marginal; inner canal openings 6-7 in 10 μ, one between each pseudoseptum-secondary pseudoseptum pair. Pseudosepta 3 in 10 μ, betweem them 1-2 secondary pseudosepta.

Discussion: Frustules of Denticula denticulata differ from those of D. hustedtii by the presence of septa, the apparently much reduced valve chambers (due to the thick, strongly silicified crossbars of the septa), and frequently by the irregular size and shape of these chambers in a given specimen. Frustules of D. denticulata differ from those of D. lauta, D. miocenica and D. nicobarica by the presence of 2 septa per frustule and by the presence of secondary pseudosepta, and from those of D. hyalina and D. homoantarctica by the presence of secondary pseudosepta and the porous valves. _D. seminae_ has finer, more numerous striae on the valve faces and also has a much different stratigraphic range than does _D. denticulata._

Features which characterize frustules of _Denticula denticulata_ are distinguishable only with great difficulty using a light microscope. Definitive identification on the basis of the microstructures outlined in the Description requires at least supplimentary use of the electron microscope.

The holotype is kept in the Orton Museum of Geology at The Ohio State University and is catalogued under the number 32792.

Denticula lauta Bailey, 1854
Plate 3, figs. 1-8

Denticula lauta Bailey, 1854, p. 9, figs. 1-2, cited in Van Landingham, 1969, p. 1274 (complete synonymy through 1969).

? D. dimorpha Schrader, 1973, p. 704, pl. 1, figs. 37-46.

Description: Frustule rectangular in girdle view. Pervalvar axis 6.5-9μ. Single epi-intercalary band, narrow, moderately silicified, open, not bearing septal plate; single apical row of pores perforates this band. Hypo-intercalary band, thick, strongly silicified, hyaline, closed, bears septum; crossbars of septal plate 4-6 in 10μ, continuous with main part of intercalary band. Weakly silicified valvocopula overlapping mantle of hypovalve. Valve elliptical to linear-elliptical, ends broadly rounded. Apical axis 7.5-57μ, transapical axis 4-9μ. Valves perforated by small circular pores in decussate arrangement, thus forming transapical striae, 18-28 in 10μ, and oblique rows, 22-24 in 10μ. Pores more numerous on mantle, 40-46 pervalvar striae in 10μ. Raphe marginal; 4-6 inner canal openings in 10μ, one between each pair of pseudosepta. Pseudosepta 4-6 in 10μ, separated by short, rib-like wall thickenings on mantle side on which raphe is located; such wall thickenings may also occur on opposite side. Secondary pseudosepta, if present, only in polar chambers and are a result of anastomosing of a more or less strongly developed siliceous thickening that protrudes into those chambers from the poles.

Discussion: Frustules of Denticula lauta differ from those of D. hustedtii and D. denticulata by the absence of secondary pseudosepta, and from those of D. hyalina by the porous valve faces and generally finer mantle structure.

The description of Denticula lauta differs from that of D. dimorpha (Schrader, 1973) in noting the porous valve faces in the former. However, the great similarities between specimens of D. lauta encountered in this study and specimens of D. dimorpha figured by Schrader gives rise to questions concerning the affinities of these two species. The configuration of the girdle structures of D. lauta illustrated herein (pl. 3, figs. 1, 8) bears close resemblance to that in the type specimen of D. dimorpha (Schrader, 1973, pl. 1, fig. 42). In addition, those of Schrader's figures that illustrate views of the valvar plane (Schrader, 1973, pl. 1, figs. 43-46) appear to be pictures of septal plates, similar to those of D. lauta described and figured herein (pl. 3, figs. 5,7), and probably do not illustrate the valve itself.

EXPLANATION OF PLATE 1

Figures 1-5 <u>Denticula hyalina</u> , Newport Bay - 4

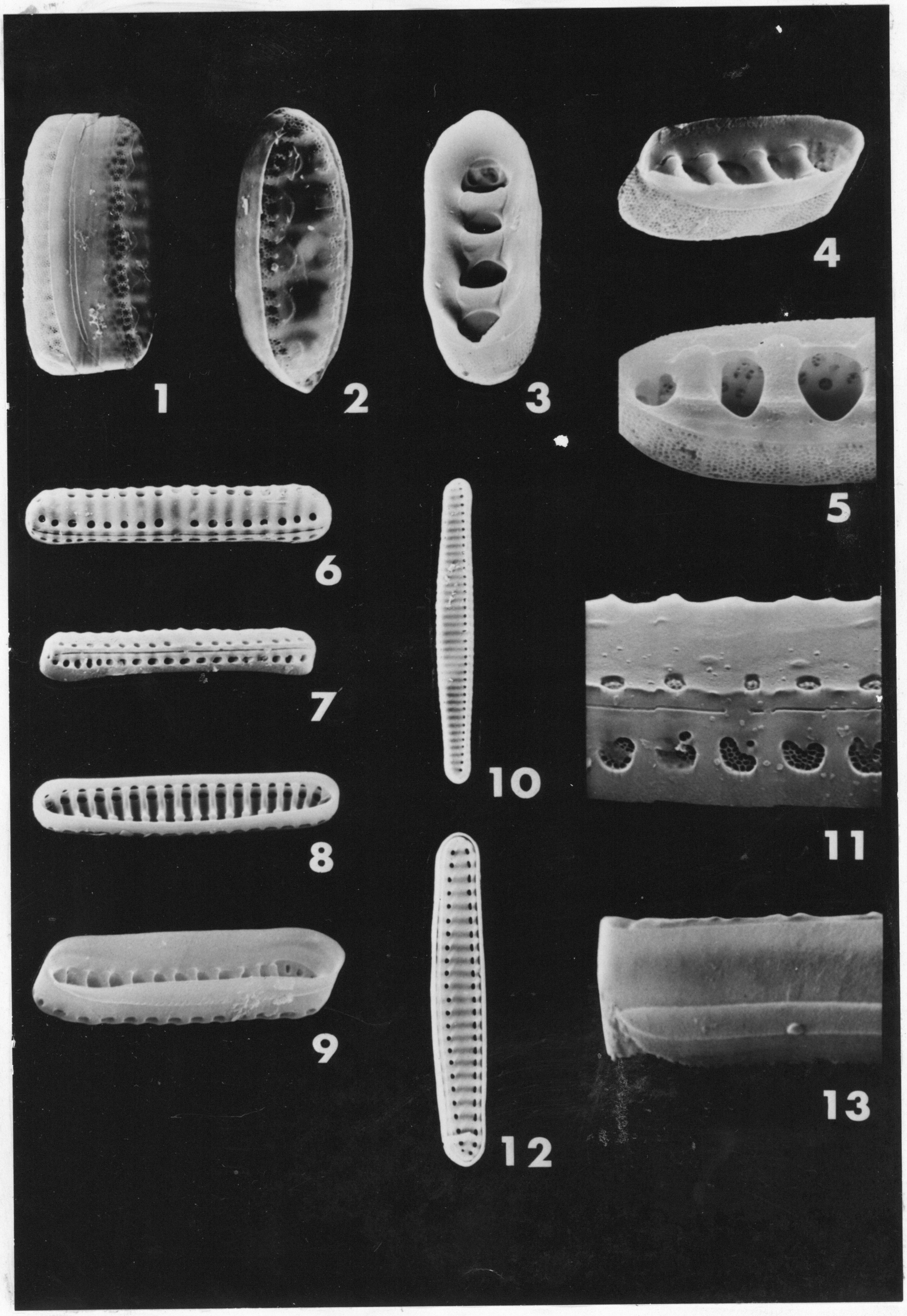
1. SEM x2027 , complete frustule
2. SEM x3093 , valve + valvocopula
3. SEM x3900 , valve + open intercalary band
4. SEM x3750 , valve + open intercalary band, note sutures between band and edges of pseudosepta
5. SEM x5700 , valve, showing double wall structure of mantle

Figures 6-13 <u>Denticula homoantarctica</u> , Eltanin 36-16-2 (560)

6. SEM x1950 , valve face
7. SEM x1870 , girdle view of specimen 6
8. SEM x1725 , interior view of valve
9. SEM x2480 , valve + open intercalary band
10. SEM x912 , exterior view of valve with vela intact
11. SEM x6985 , cribrum type vela of specimen 10
12. SEM x1350 , valve + valvocopula
13. SEM x8750 , girdle view of specimen 12, showing valvocopula and one open intercalary band

PLATE 1

PLATE 1



EXPLANATION OF PLATE 2

Figures 1-7 <u>Denticula hustedtii</u> , DSDP 329-10-cc

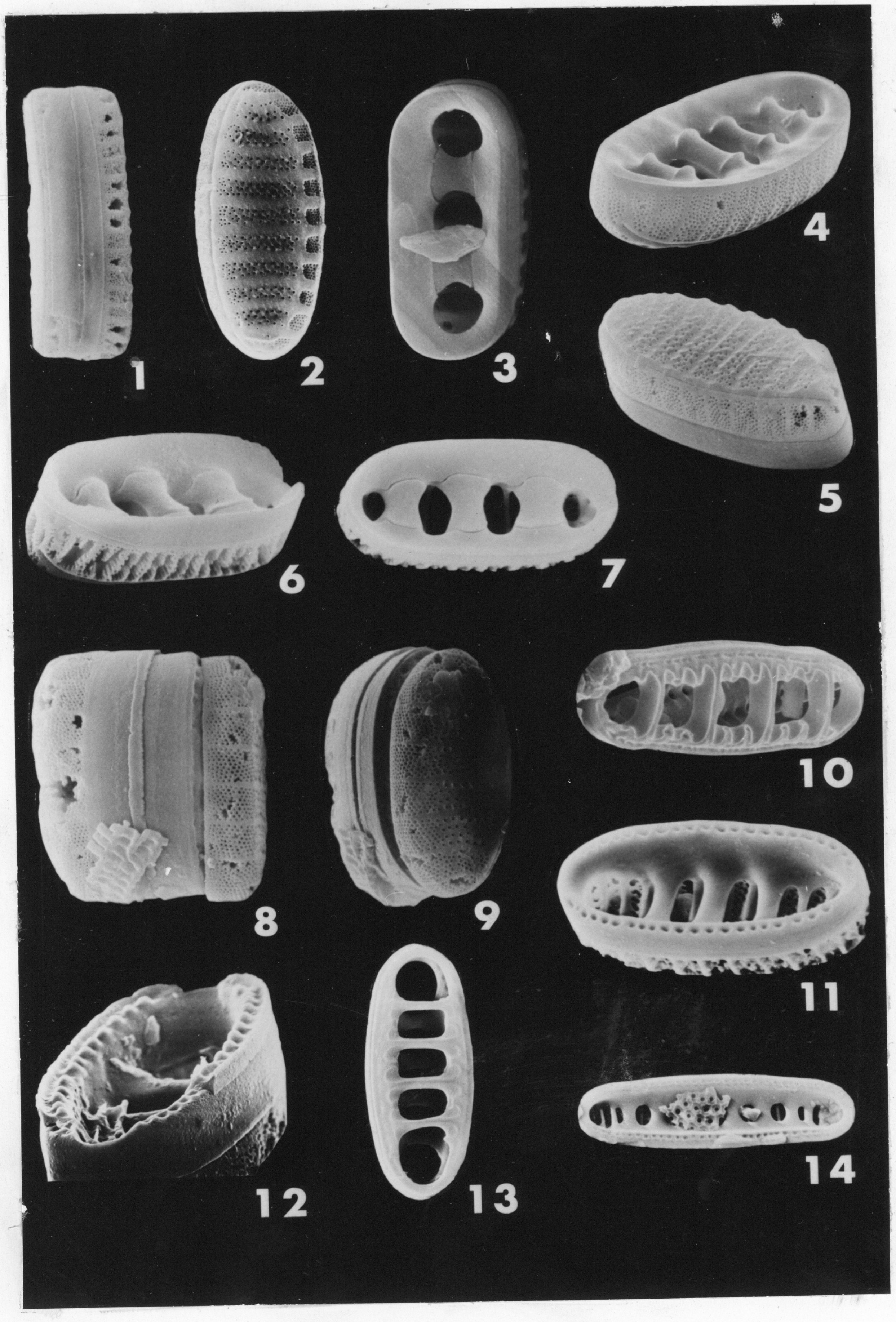
1. SEM x1572 , complete frustule
2. SEM x2130 , valve face
3. SEM x2981 , valve + closed intercalary band
4. SEM x2720 , interior view of valve
5. SEM x2545 , valve + closed intercalary band
6. SEM x3500 , valve + open intercalary band
7. SEM x3110 , interior view of specimen 6

Figures 8-14 <u>Denticula denticulata</u> , DSDP 329-22-cc

8. SEM x3300 , complete frustule
9. SEM x3300 , oblique view of specimen 8
10. SEM x2490 , advalvar side of closed intercalary band with septum
11. SEM x2425 , valve + intercalary band with septum, note depressions on abvalvar rim of band
12. SEM x4343 , valve + intercalary band + connecting band, note denticles on connecting band
13. SEM x2225 , two septal plates bound by connecting band
14. SEM x1395 , interior view of valve + septal plate

PLATE 2

PLATE 2



EXPLANATION OF PLATE 3

Figures 1-8 Denticula lauta

1. SEM x2325 , complete frustule, girdle view
   DSDP 329-24-cc

2. SEM x2300 , oblique view of specimen 1

3. SEM x1881 , valve face
   DSDP 329-10-cc

4. SEM x2950 , interior view of valve
   DSDP 328-3-3

5. SEM x2792 , interior view of closed intercalary band with septum
   DSDP 329-23-cc

6. SEM x2765 , interior view of valve + open intercalary band without septum
   DSDP 329-24-cc

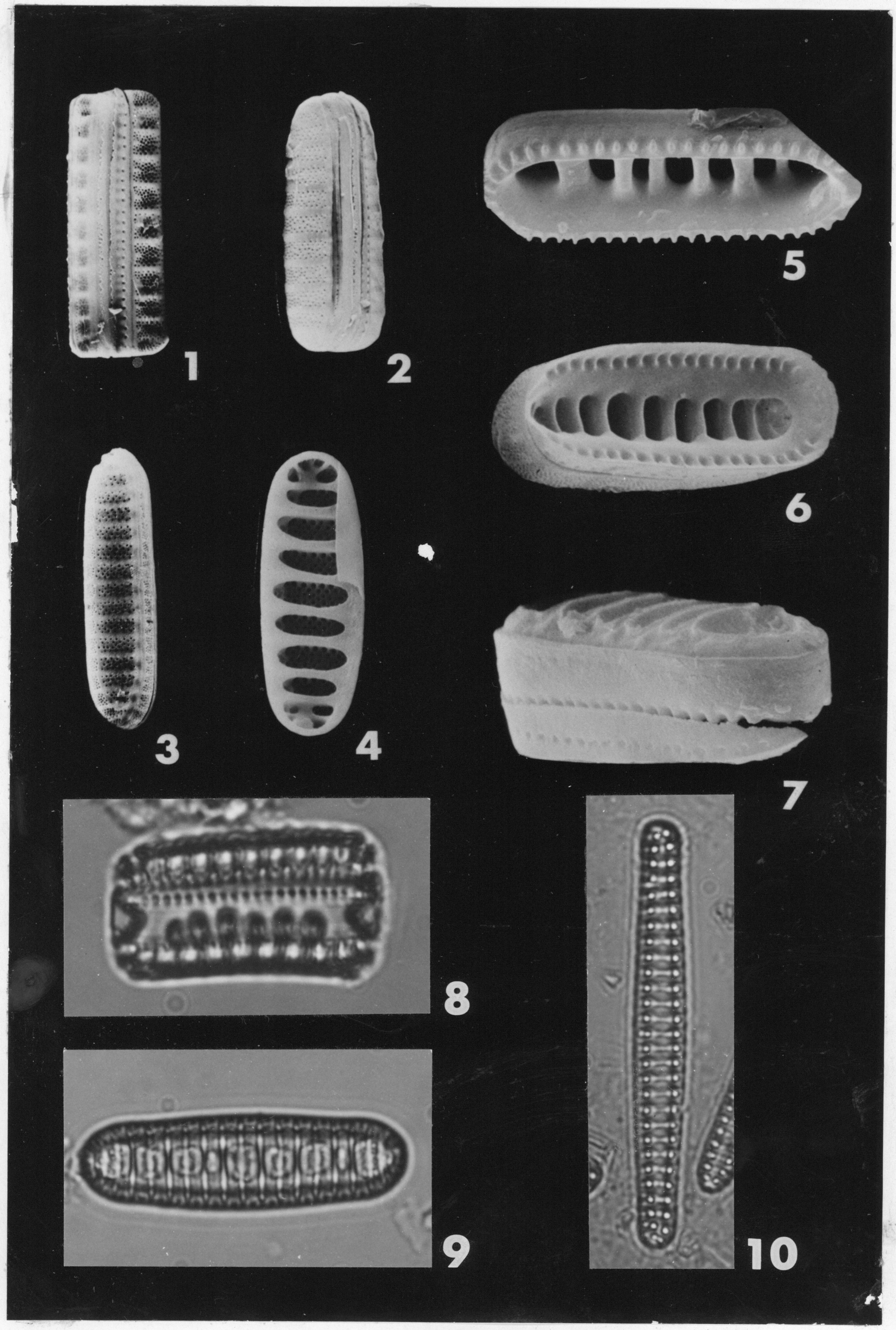
7. SEM x3465 , closed intercalary band with septum + open intercalary band
   DSDP 329-23-cc

8. LM x2525 , girdle view of complete frustule
   DSDP 329-24-cc

Figure 9. Denticula denticulata, holotype
LM x2550 , interior view of valve + intercalary band with septum
DSDP 329-22-cc

Figure 10. Denticula homoantarctica, holotype
LM x1850 , exterior view of valve face
Eltanin 36-16-2 (560)

PLATE 3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REFERENCES:

Anonymous, 1974. Proposals for a Standardization of Diatom Terminology and Diagnosis, In R. Simonsen, ed., Third Symposium on Recent and Fossil Marine Diatoms: Nova Hedwigia, Beih. 53, pp. 323-354.

Frakes, L. A., 1971. USNS Eltanin Core Descriptions, Cruises 32-45: Florida State University Sedimentology Research Laboratory Report, 105 pp.

Gombos, A. M., in press. Paleogene and Neogene diatoms from the Falkland Plateau and Malvinas Outer Basin, Leg 36: Initial Reports of the Deep Sea Drilling Project, Vol. XXXVI.

Hendey, N. I., 1964. Bacillariophyceae, In An introductory account of the smaller algae of British coastal waters, part V, 317 pp.: Fishery Invest Ser. IV.

Ingle, J. C., 1973. Biostratigraphy and paleoecology of early Miocene through early Pleistocene benthonic and planktonic foraminifera, San Joaquin Hills - Newport Bay - Dana Point area, Orange County, Calif., In P. Fischer and D. Johnson, eds., Miocene sedimentary environments and biofacies, southeastern Los Angeles basin: SEPM trip 1, guidebook, annual meeting of the AAPG, SEPM, SEG.

McCollum, D. W., 1975. Diatom stratigraphy of the southern ocean: Initial Reports of the Deep Sea Drilling Project, Vol. XXVII, pp. 515-571.

Patrick, R. and Ch. W. Reimer, 1966. The diatoms of the U. S., Vol. 1, 688pp.: Monogr. of the Acad. of Nat. Sci. Philadelphia.

________ 1975. The diatoms of the U. S., Vol. 2, 273pp.: Monogr. of the Acad. of Nat. Sci. Philadelphia.

Round, F. E., 1972. The formation of Girdle, Intercalary Bands, and Septa in Diatoms: Nova Hedwigia, Beih. 23, pp. 449-463.

Schrader, H. J., 1973. Cenozoic diatoms from the Northeast Pacific, Leg 18: Initial Reports of the Deep Sea Drilling Project, Vol. XVIII, pp. 673-797.

________ 1973. Stratigraphic distribution of marine species of the diatom Denticula in Neogene North Pacific sediments: Micropaleontology, Vol. 19, no. 4, pp. 417-430.

Schrader, H. J., in press. Cenozoic marine plankton diatom biostratigraphy of the Southern Pacific Ocean: Initial Reports of the Deep Sea Drilling Project, Vol. XXXV.

Simonsen, R. and T. Kanaya, 1961. Notes on the Marine Species of the Diatom Genus Denticula Kutz: Internat. Rev. Ges. Hydrobiol., 46, pp. 498-513.

Van Landingham, S. L., 1969. Catalogue of the fossil and recent genera and species of diatoms and their synonyms, Vol. 3, pp. 1269-1280: Lehre, Cramer.

Von Stosch, H. A., 1974. An Amended Terminology of the Diatom Girdle In R. Simonsen, ed., Third Symposium on Recent and Fossil Marine Diatoms: Nova Hedwigia, Beih. 53, pp. 1-36.